

RF Breakdown Prevention in Spacecraft Components Product Overview

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RF Breakdown Prevention in Spacecraft Components

Product Overview

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May 8, 2014

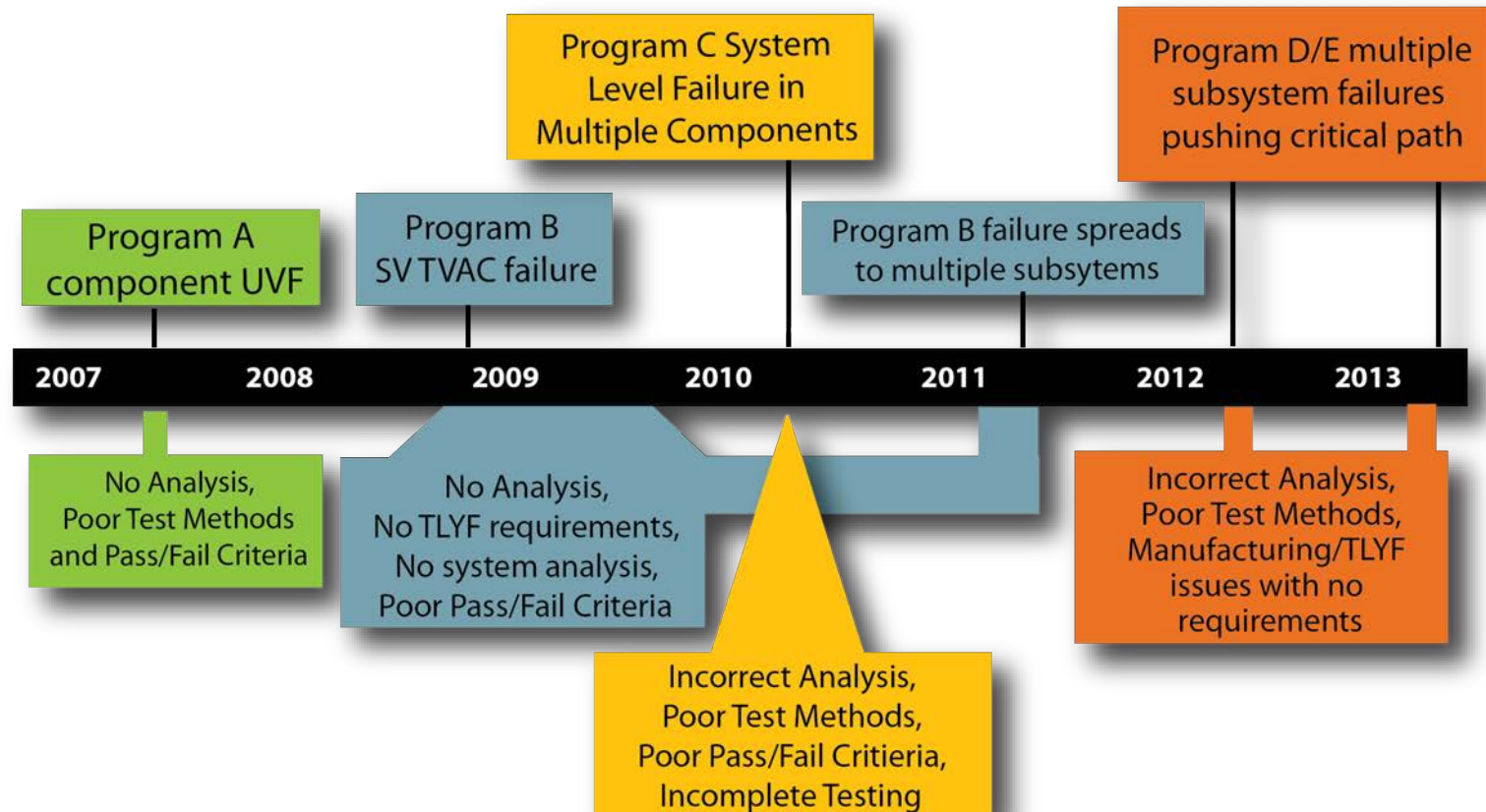
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U.S. SPACE PROGRAM MISSION ASSURANCE IMPROVEMENT WORKSHOP
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Motivation for RF Breakdown Prevention Standard

Problem Statement

- Ionization breakdown and multipactor causing multiple failures in RF components
 - Increasing satellite powers and bandwidth requirements will continue to increase risk
- Significant ground/on-orbit failures on current programs
 - High power filters, isolator devices, antenna system components
- Reliance on limited SME support, minimal standardization/TLYF/design criteria



Motivation for RF Breakdown Prevention Standard

System Analysis and Requirements

- Different approach for many programs, suppliers, etc.
- Worst case analysis, risk assessment for system and component susceptibility

Need: Uniform baseline for defining worst-case, bounding requirements

Component Design

- Large margins required due to model uncertainty, no standard process
- Modern analysis tools and mitigation techniques

Need: Better numerical and prediction tool implementation

Ground Test and Integration

- Detection and requirements difficult
- Test diagnostic implementation, test-like-you-fly requirements

Need: More sensitive and standardized diagnostics, test-like-you-fly requirements

MAIW Goals

- Develop new Standard to directly impact US RF satellite industry
- Provide guidance for requirement baselines with industry insight
- Address deficiencies in previous/current processes
- Outline future directions for research to aid industry



Agenda

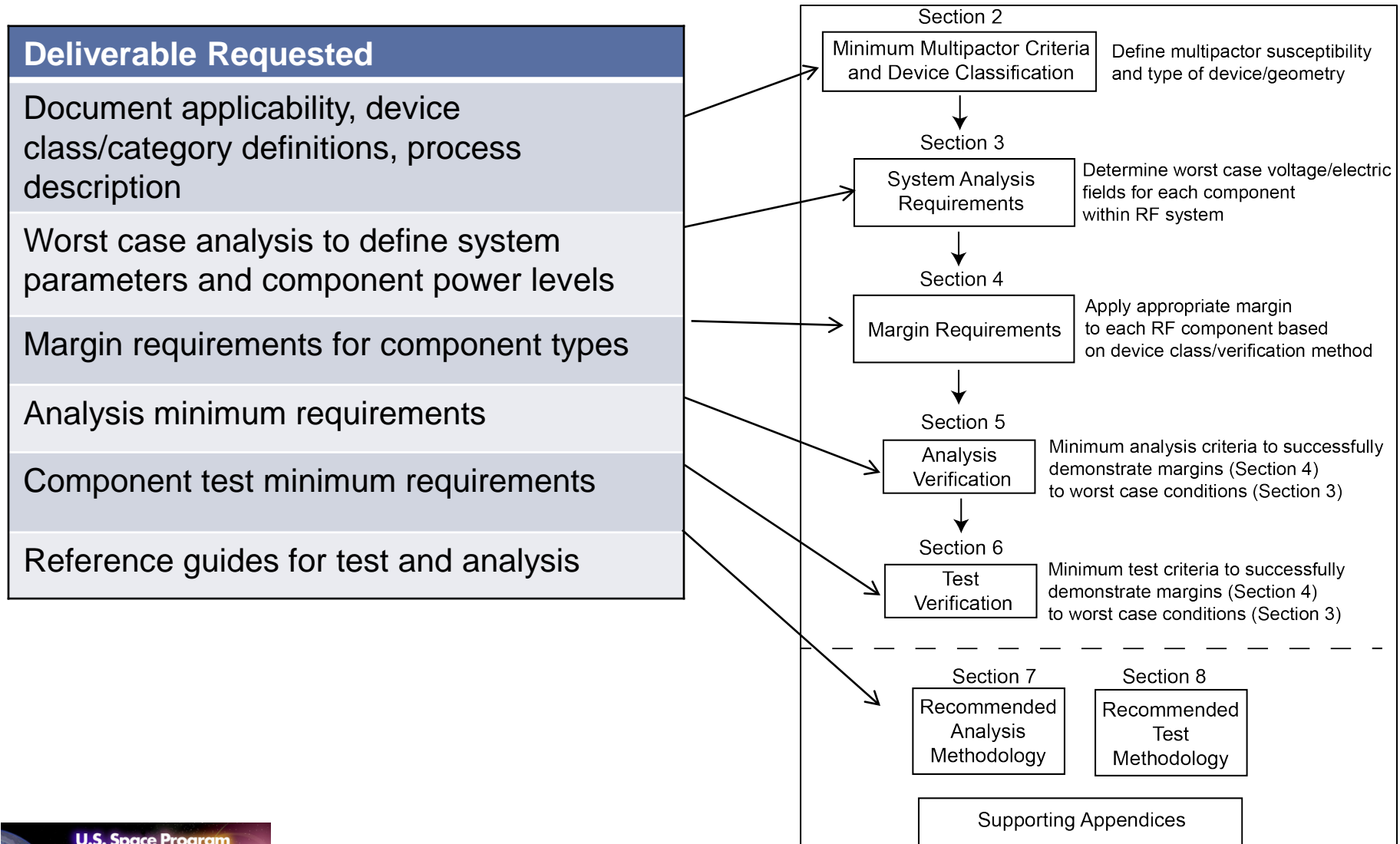
- Product overview of RF breakdown prevention process
 - *Minimum multipactor criteria*
 - *Worst case system analysis*
 - *Margin requirements and verification process requirements*
- SME comments and Workshop products
- Document intended use
 - *Agency adoptions, customer/contractor/supplier implementation*
- Topic Follow-on Recommendations
 - *Future effort to enhance this document and support other classes of RF breakdown*
- Team Membership and Recognition



RF Breakdown Prevention Standard Charter

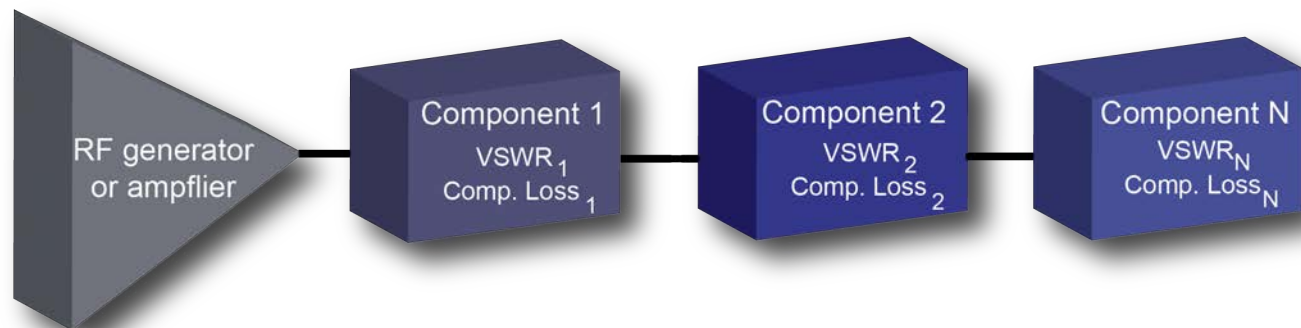
- Develop industry-wide standard for component, subsystem, and system test with respect to RF breakdown risk mitigation in RF/microwave components
 - *Define system analysis process to determine worst case, bounding conditions for each component*
 - *Define minimum requirement set for analysis and test to ensure proper treatment and consideration*
 - *Reference guides for analysis and test recommended techniques*
 - *Provide standard test geometries for analysis and test facility benchmarking*
 - *Describe areas in need of further research*
 - *Recommend industry adoption (Standard/Handbook adoption)*

RF Breakdown Prevention Standard – Product Traceability



Product Overview – A New Process Approach

- Standard/Handbook for RF breakdown – multipactor discharge specific
 - *Ionization breakdown/corona to be covered in follow-up year*
- Defining minimum multipactor criteria and device classifications
 - *Allow process tailoring for broad applicability across many system types*
- Full process approach to determine worst case for each component
 - *Improvement over “lumping” excess margin to cover multiple uncertainties*
 - *Define worst case power based on bounding and predictable variables*
 - *Each section of document builds on previous sections*

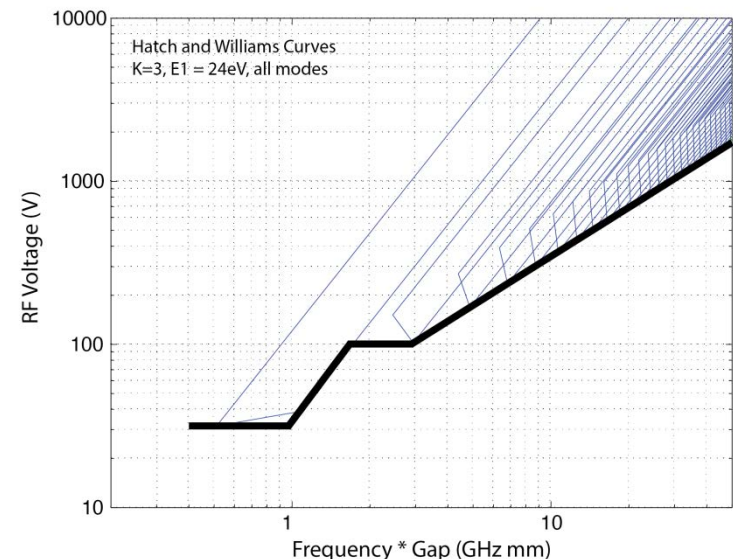


Product Overview – New requirement definitions

- Defining margin requirements
 - Using worst case system analysis, provide requirements for margins*
- Realistic requirements supported by full process approach

Complexity Level	Analysis Margin (dB)			Test Margin (dB)	Example
	Type 1	Type 2	Type 3	Type 1/Type 2/Type 3	
1	3	3	N/A	3	1-D Transmission Line
2	3	6	N/A	3	Stepped Impedance
3	3	6	N/A	3	Resonant Cavity

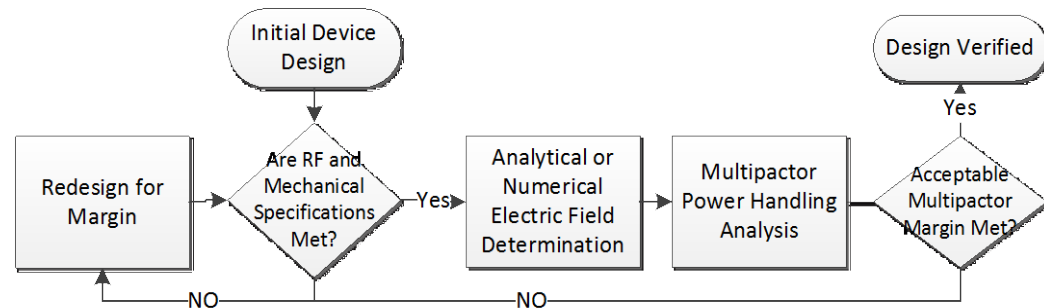
- Requirement verification: Minimum criteria
 - Analysis: Minimum requirements for modern methods and tools*
 - Test: TLYF implementation for proper screening/detection*



Product Overview – Recommended Methods

- Guidance/Recommendations for analysis and test methods
 - Provide industry best practices for both analysis and test*

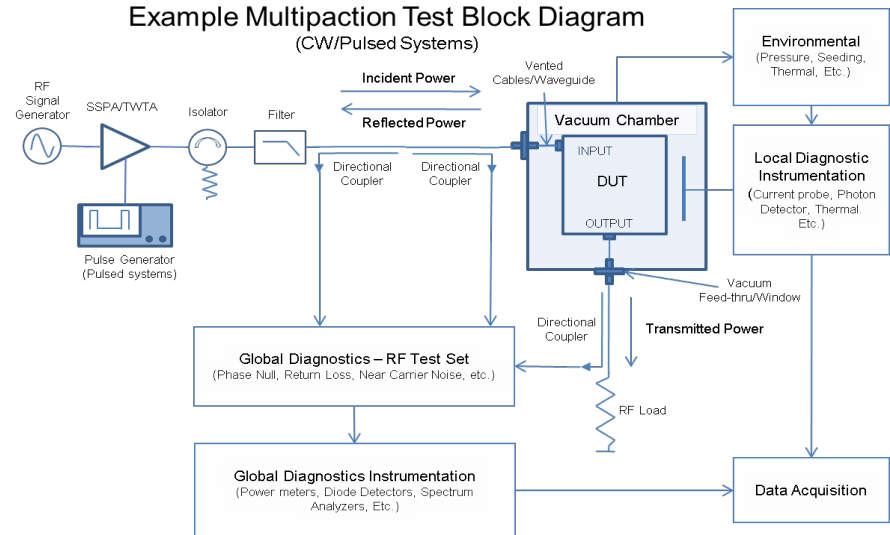
- Analysis techniques: process description and recommendations



- Proper testing: examples and considerations

- Data collection*
- Recommended diagnostics*
- Pass/Fail Criteria*
- Test operation*

Example Multipaction Test Block Diagram
(CW/Pulsed Systems)



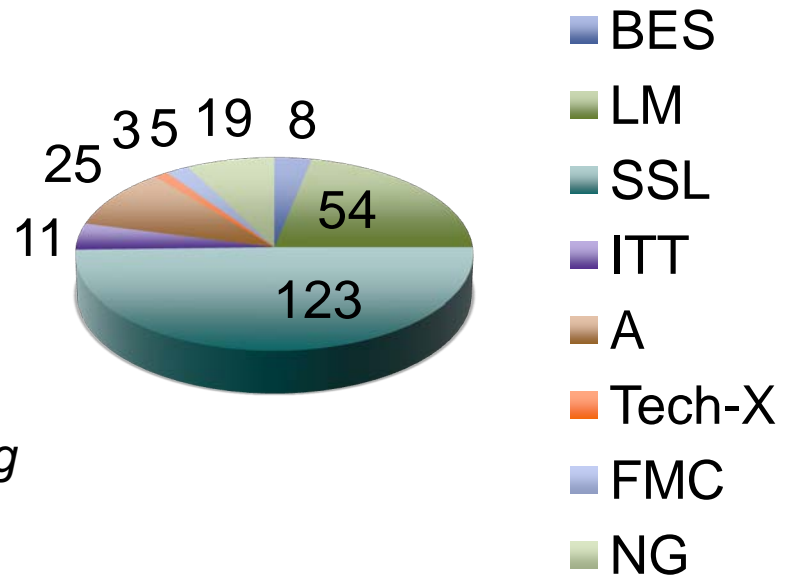
Workshop Objectives and Accomplishments

- Incoming objectives of workshop
 - ✓ *Agreement on process elements – worst case, baseline conditions for analysis and test*
 - ✓ *Comparison to other documents and rationale for differences*
 - ✓ *Rationale for minimum verification requirements*
 - ✓ *Document structure including multiple volumes, handbook versus standard*
- Workshop Accomplishments
 - ✓ *Dispositioned all SME comments*
 - ✓ *No major or technical actions, only remaining to refine document language*
 - ✓ *Action ECD May 14, 2014*
 - ✓ *Discussed proposed follow-on activities*



Disposition of Comments

- Over 250 comments from SMEs, currently dispositioning in small committee meetings
 - *Comments coming in from vendors, contractors, and customer communities*
 - *99% have been discussed and implemented*
- Common themes with comments
 - ✓ *Formatting for standard adoption (refining to shall statements)*
 - ✓ *Comparison to previous (ESA) methods*
 - ✓ *Use of different materials in the analysis margin determination*
 - ✓ *Applying system analysis to any system*
 - ✓ *Thermal requirements for multipactor testing*
 - ✓ *Defining pass fail criteria*
 - ✓ *Multicarrier power definition – not covered in FY14 effort*



Intended Product Use (1 of 2)

- Improved “front-end” guidance for multipactor risk mitigation for RF/microwave spacecraft components
 - *Applicability for all parties within the component life cycle*
 - Customer: Requirement definition
 - Contractor: System engineering requirement flow-down to suppliers
 - Supplier: Minimum requirement set for analysis and test
 - *Product will be updated with future improvements in analysis and test methods*
 - *Margin requirements can be updated based on new/updated data*
- Implementation for any spacecraft system
 - *Applicable for government, civil, and commercial systems*
- Customer benefit to incorporating Standard
 - *Developed cooperatively by industry, uses modern-day tools, provides end-to-end risk mitigation process*



Intended Product Use (2 of 2)

- Long term goal: document in contract language from program initiation
 - *Current programs still experiencing issues, document features already in use*
- Creation of “official” Standard and agency adoption
 - *Determine potential adopting agencies via DoD, IEEE, AIAA, etc.*
 - *Technical communication/vetting through conferences, international collaboration*
 - Slated for 2015 Workshop in RF Breakdown, International Microwave Symposium
- Standard will drive future research for improved scientific understanding and engineering techniques
 - *Multicarrier, surface treatments, advanced diagnostics require support for development*
 - *Current Multidisciplinary University Research Initiative (MURI) effort under investigation*
 - RF breakdown is inherently multi-disciplinary: RF engineering, plasma physics, surface science
 - Need for new innovation and industrial expert base – foster through university research



Topic Follow-on Recommendations

- Standard Adoption (Agency, Formatting, Multi-volume document)
- Multicarrier power definition
 - *Research currently underway at Aerospace with initial green light from industry*
 - *Further work to refine method and apply to different complex systems*
- Ionization breakdown requirements and minimum verification requirements
 - *No existing document in any forum, domestic or international*
 - *Research necessary to refine requirements*
 - *Potential for new volume within existing document – many general principals, diagnostics are similar*
- MURI investigation for future RF breakdown research



Team Introductions



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Exelis Inc.	Kevin Campbell	Luigi Greco
JPL	Mike Settember	Douglas Dawson, Richard Hodges
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Flight Microwave Corp.		Richard Bennett
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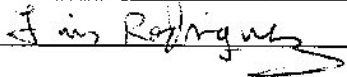
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